

## CLAIMS

1. A method of producing a hologram from a virtual object (6) defined in a three-dimensional geometrical space (O,x,y,z), characterized in that it includes the following steps:

5 computing (E1-E4) a set of two-dimensional images ( $80_{nm}$ ) representing the object from respective different viewpoints in the three-dimensional space,

computing (E5-E6) holograms ( $90_{nm}$ ) respectively corresponding to said two-dimensional images, and

10 combining (E7) said holograms ( $90_{nm}$ ) to form a hologram (9) of the object (6).

2. A method according to claim 1, wherein said step of computing the set of two-dimensional images includes the following steps:

15 defining (E1-E2) in the three-dimensional space a matrix of points ( $70_{nm}$ ) in a first geometrical plane (7) separate from the object (6), and

projecting (E3-E4) images of the object as respectively seen from said points ( $70_{nm}$ ) of said matrix onto a second geometrical plane (8) which is preferably between the object (6) and the first plane (7) and parallel to the first plane, the projected images constituting said two-dimensional images ( $80_{nm}$ ).

20 3. A method according to claim 2, wherein, for each point ( $70_{nm}$ ) of the matrix, said projection step consists of projecting points (60) of the object (6) onto the second plane (8) along respective straight lines passing through said points of the object and said each point of the matrix.

25 4. A method according to any one of claims 1 to 3, wherein said step (E5-E6) of computing the holograms is implemented using a technique employing a Fourier transform.

30 5. A method according to any one of claims 1 to 4, wherein said two-dimensional images ( $80_{nm}$ ) are defined by respective real functions ( $f_{nm}(Y,Z)$ ) and said step (E5-E6) of computing the holograms comprises the following steps for a given two-dimensional image ( $80_{nm}$ ):

transforming (E50, E51) the given two-dimensional image defined

by the corresponding real function into a complex two-dimensional image defined by a complex function,

oversampling (E52) the complex image (82<sub>nm</sub>),

5 simulating (E53) the production of a diffracted image resulting from the diffraction of an optical wave (DIF) by the oversampled complex image (83<sub>nm</sub>),

adding (E54) a complex field representing a reference optical wave (REF) to the resulting diffracted image (84<sub>nm</sub>), and

10 encoding (E6) values taken by the amplitude of the sum of said complex field and the resulting diffracted image (84<sub>nm</sub>) to produce the hologram (90<sub>nm</sub>) associated with said given two-dimensional image (80<sub>nm</sub>).

6. A method according to claim 5, wherein said transform step includes the following steps:

15 determining (E50) amplitude values each depending on the square root of a corresponding value taken by said real function, and

associating (E51) a phase with each of said amplitude values so that an amplitude value and a phase value are defined for each point of the complex image.

7. A method according to claim 5 or claim 6, wherein said simulation step (E53) includes the computation of at least one of the following complex transforms: Fourier transform, Walsh transform, Hankel transform, orthogonal polynomial transform, Hadamar transform, Karhunen-Loeve transform, multiresolution discrete wavelet transform, adaptive wavelet transform and a transform consisting of a composite of 25 at least two of the above transforms.

8. A method according to claim 7, wherein said simulation step (E53) consists of computing a convolutional product, associated with the oversampled complex image, of two components, by applying the transform which is the inverse of said complex transform to the product of 30 the respective complex transforms of said two components.

Q 9. A method according to any one of claims 1 to 8, wherein said step (E7) of combining the holograms comprises juxtaposing the holograms

(90<sub>nm</sub>) of the two-dimensional images (80<sub>nm</sub>) in a common digital image (9) constituting said hologram (9) of the object (6).

10. A method of producing a three-dimensional image from a virtual object (6) defined in a three-dimensional geometrical space (O,x,y,z), characterized in that it includes the following steps:

5 producing a hologram (9) of the object (6) by the method according to any one of claims 1 to 9,

physically reproducing (E8) said hologram (9) of the object (6) on a spatial light modulator (2), and

10 illuminating (E8) the spatial light modulator (2) in order to reproduce a three-dimensional image of the object (6) from the hologram (9).

11. A method according to claim 10, wherein said spatial light modulator (2) comprises a liquid crystal screen having a pixel pitch less than 10  $\mu\text{m}$  and preferably from 1  $\mu\text{m}$  to 2  $\mu\text{m}$  in at least two different directions.

12. A method according to claim 10 or claim 11, wherein the step of illuminating the spatial light modulator (2) consists of illuminating it with three optical waves (4a, 4b, 4c) respectively representing the colors red, green and blue (RGB) in turn and in synchronism with reproduction by the spatial light modulator (2) of a sequence of holograms of the object produced by a method according to any one of claims 1 to 9 and each corresponding to one of said three colors, so that a three-dimensional color image of the object (6) is reproduced.

13. A method according to any one of claims 10 to 12, wherein a sequence of holograms is physically reproduced by the spatial light modulator (2) and each of the holograms of the sequence is produced by a method according to any one of claims 1 to 9, so that after the step of illuminating the spatial light modulator animated three-dimensional images of the object (6) are reproduced.

14. A system for producing a hologram from a virtual object (6) defined

in a three-dimensional geometrical space (O,x,y,z), characterized in that it includes:

means (1) for storing in memory the virtual object (6) defined in the three-dimensional geometrical space (O,x,y,z),

5 first computing means (1) for producing a set of two-dimensional images (80<sub>nm</sub>) representing the object (6) from respective different viewpoints in the three-dimensional space,

second computing means (1) for producing holograms (90<sub>nm</sub>) respectively corresponding to said two-dimensional images (80<sub>nm</sub>), and

10 combining means (1) for combining said holograms (90<sub>nm</sub>) to form a hologram (9) of the object (6).

15 15. A system according to claim 14, wherein said first computing means comprise projection computing means (1) for computing the projection of images of the object (6) as seen from respective points (70<sub>nm</sub>) of a matrix of points in a first geometrical plane (7) separate from the object (6) onto a second geometrical plane (8) which is preferably between the object (6) and the first plane (7) and parallel to the first plane (7) in the three-dimensional geometrical space (O,x,y,z).

20 16. The system claimed in claim 15, wherein said projection computing means comprise means (1) for computing, for each point (70<sub>nm</sub>) of the matrix, the projection of points (60) of the object (6) onto the second plane (8) along respective straight lines passing through said points of the object and said each point of the matrix.

25 17. A system according to ~~any one of claims 14 to 16~~ wherein said two-dimensional images (80<sub>nm</sub>) are defined by respective real functions (f<sub>nm</sub>(Y,Z)) and the second computing means comprise:

transform means (1) for transforming (E50, E51) a given two-dimensional image (80<sub>nm</sub>) defined by a corresponding real function into a complex image defined by a complex function,

30 means (1) for oversampling (E52) the complex image,

simulator means (1) for simulating (E53) the production of a diffracted image resulting from the diffraction of an optical wave (DIF) by the oversampled complex image,

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means (1) for adding (E54) a complex field representing a reference optical wave (REF) to the resulting diffracted image ( $84_{nm}$ ), and  
means (1) for encoding (E6) values taken by the amplitude of the sum of said complex field and the diffracted image ( $84_{nm}$ ) to produce the hologram ( $90_{nm}$ ) associated with said given two-dimensional image ( $80_{nm}$ ).  
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18. A system according to claim 17, wherein said transform means comprise:

means (1) for determining (E50) amplitude values each depending on the square root of a corresponding value taken by said real function,  
10 and

means (1) for associating (E51) a phase with each of said amplitude values so that an amplitude value and a phase value are defined for each point of the complex image.

Q 19. A system according to claim 17 or claim 18, wherein said simulator  
15 means comprise means (1) for computing one of the following complex transforms: Fourier transform, Walsh transform, Hankel transform, orthogonal polynomial transform, Hadamar transform, Karhunen-Loeve transform, multiresolution discrete wavelet transform, adaptive wavelet transform and a transform consisting of a composite of at least two of the  
20 above transforms.

20. A system according to claim 19, wherein said simulator means comprise means (1) for computing a convolutional product, associated with the oversampled complex image, of two components, by applying the transform which is the inverse of said complex transform to the product of  
25 the respective complex transforms of said two components.

Q 21. A system according to any one of claims 14 to 20, wherein the combining means (1) comprise means for juxtaposing the holograms ( $90_{nm}$ ) of the two-dimensional images ( $80_{nm}$ ) in one digital image (9) constituting said hologram of the object (6).

30 22. A system for producing a three-dimensional image from a virtual object (6) defined in a three-dimensional geometrical space (O,x,y,z),

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characterized in that it comprises:

a system according to any one of claims 14 to 21 for producing a hologram (9) of the object (6),

5 a spatial light modulator (2) for physically reproducing the hologram (9) of the object, and

a light source (4) for illuminating the spatial light modulator (2) in order to reproduce a three-dimensional image of the object (6) from the hologram (9).

10 23. A system according to claim 22, wherein said spatial light modulator (2) comprises a liquid crystal screen having a pixel pitch less than 10  $\mu\text{m}$  and preferably from 1  $\mu\text{m}$  to 2  $\mu\text{m}$  in at least two different directions.

15 24. A system according to claim 22 or claim 23, wherein said light source comprises three separate light sources (4a, 4b, 4c) for illuminating the spatial light modulator (2) with three optical waves respectively representing the colors red, green and blue (RGB) in turn and in synchronism with the reproduction by the spatial light modulator (2) of a sequence of holograms of the object produced by a system according to any one of claims 14 to 21 and each corresponding to one of said three colors so that a three-dimensional color image of the object is reproduced.

20 25. A system according to any one of claims 22 to 24, wherein said system according to any one of claims 14 to 21 is on a first site, the spatial light modulator (2) and the light source (4) are on a second site and the first and second sites are remote from each other.

*Claim 22*